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CENTRAL AUDITORY ABILITIES OF NORMAL AND LOWER GROUP READERS.

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THE GOALS OF THE REPORTED RESEARCH WERE (1) TO EVALUATE THE HEARING IN EARLY-ELEMENTARY-SCHOOL-AGED CHILDREN IN A REGULAR PUBLIC SCHOOL READING PROGRAM, (2) TO COMPARE THE AUDITORY AND PERCEPTUAL ABILITIES OF CHILDREN WHO CAN AND CHILDREN WHO CANNOT DO THE NORMAL READING FOR THEIR GRADE, AND (3) TO SEARCH FOR RELATIONS BETWEEN READING ACHIEVEMENT AND CENTRAL AUDITORY SKILLS. SUBJECTS WERE SELECTED FROM THIRD-GRADE PUBLIC SCHOOL CHILDREN AND WERE DIVIDED INTO A CONTROL GROUP (NORMAL READING) AND AN EXPERIMENTAL GROUP (LOW READING), EACH GROUP CONSISTING OF 41 SUBJECTS. SELECTION CRITERIA WERE BASED ON PERFORMANCE SCORES FOR THE STANFORD ACHIEVEMENT TEST, THE CALIFORNIA MENTAL MATURITY SCALE, AND THE PEABODY PICTURE VOCABULARY TEST. SUBJECTS WERE TESTED UNDER CONDITIONS OF LOW PASS FILTERED SPEECH, ACCELERATED SPEECH, DUAL DISTORTION, AND COMPETING MESSAGES. RESULTS DEMONSTRATED SIGNIFICANT CORRELATION BETWEEN READING ACHIEVEMENT AND AUDITORY ABILITIES WHICH INDICATED THAT MEASURES OF CENTRAL HEARING MAY BE OF PROGNOSTIC VALUE RELATIVE TO FUTURE READING ACHIEVEMENT AND/OR DISABILITY. THE FINDINGS SUGGESTED THAT (1) TESTS OF CENTRAL AUDITORY ABILITIES MAY MAKE POSSIBLE EARLY IDENTIFICATION OF CHILDREN WHO WILL EXPERIENCE DIFFICULTY IN PHONICS LEARNING DURING THE READING READINESS PROGRAM, AND (2) THE COMPETING MESSAGES TECHNIQUE MIGHT BE USEFUL IN EVALUATING THE CENTRAL MECHANISM OF HEARING OF CHILDREN CONSIDERED TO BE MENTALLY HANDICAPPED OR BRAIN DAMAGED. (WB)

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Central Auditory Abilities of Normal and Lower Group Readers

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Cooperative Research Project No. S-076

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1964

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I. Statement of the Problem

Phonics skills have long been considered by many workers as skills necessary to facilitate the learning process in reading. The Boston University studies (1958) have indicated that acquisition of basic phonic skills by the child insures success in first grade reading. Assuming that auditory perceptual skills - or physiologically, an intact, well integrated central mechanism of hearing - act as a foundation for the learning and/or acquisition of these phonic skills, the problem arises of adequately evaluating these perceptual skills in children. Assuming that educators will increasingly move in the direction of phonics teaching in their reading readiness programs, a disturbing question arises: do all children possess basic auditory perceptual abilities adequate for phonics learning? The major problem then becomes: can children with inferior auditory perceptual skills be identified during and possibly prior to initiation of extensive phonics training programs?

The current problem of auditory perceptual skills and their relationship to phonics learning cannot be minimized or in any way be overemphasized. Its significance to education can be illustrated in the fact that many school aged children who manifest no overt neurological deficit have marked difficulty in learning phonic-skills, and other auditory skills, eg: auditory blending and speech-sound discrimination ability. For some children, it may be a waste of time and effort to attempt to teach phonics and auditory blending in the reading program, since the conventional (ear training) approach is inadequate for these particular children. If a child could be

identified as having a central auditory problem, such approaches, eg: "tactile-kinaesthetic-motor"; "moto-kinaesthetic"; portions of the "association method"; and/or a physiological phonetics method could be employed in the early grades. Perhaps a child in this category could benefit more from a sight vocabulary learning approach to reading. Furthermore, successful evaluation of a child's auditory perceptual abilities in kindergarten, or perhaps in the latter stages of pre-school development, could possibly identify and predict which individual children might have phonic learning difficulties resulting from an inadequate central mechanism of hearing. This kind of circumstance would preclude the use - and subsequent time waste - of conventional phonics teaching methods.

II. Objectives and Hypotheses

The research reported herein was designed to achieve the following goals:

(1) To evaluate the central mechanism of hearing of early elementary school aged children in a regular public school reading program.

(2) To compare the central auditory perceptual abilities of children who can do the normal reading for the grade (here designated the "normal reading group") and those who cannot. (The latter group will be referred to as the "slow reading group").

(3) To determine the efficacy of four special auditory tests in evaluating the central mechanism of hearing in these populations.

(4) To search for relations between reading achievement and central auditory skills.

In view of the stated objectives, the "null" hypotheses can be stated as follows: (1) there are no significant differences in central auditory abilities of early elementary school children who are normal readers and those who are classified as slow and/or "low reading group" children; and (2) no significant relationships exist between reading achievement and central auditory skills.

The problem can also be stated positively in the form of questions which also serve as working hypotheses: (1) do children in the normal reading group perform better than those in the lower reading group on tasks designed to evaluate the central mechanism of hearing (auditory perceptual abilities) and/or, are auditory perceptual abilities of normal readers significantly better than those of poorer readers; and (2) are there significant relationships to be found among various auditory perceptual skills and reading achievement level?

III. Related Research

To date, relatively little work has been initiated in attempting to evaluate central auditory abilities and their relationship to basic phonic skills considered necessary to success in first grade reading, and other auditory factors, eg: auditory blending and auditory discrimination.

A relationship between speech disorders and reading disability has been suggested by various investigators in the disciplines of

speech pathology and reading disability. Artley (1948) made the most significant observation when he concluded it is possible that either of these language difficulties may be of etiological significance relative to the other, however, it is more probable that both deficiencies are caused by a common interference such as the factor of audition.

For some time now, the discipline of Speech Pathology has been attempting to evaluate an illusive auditory sensitivity referred to as speech-sound discrimination ability. This auditory skill is viewed by the present writer and his colleagues as being a central phenomenon which should be considered an integral part of general auditory perception. It also occurs to the present investigator that the process of phonics learning - as related to reading - would require much the same kind of auditory perceptual ability necessary for speech-sound discrimination learning.

Recently, Flowers and Costello (1963, 1964) have experimented with two relatively different approaches to the assessment of basic central auditory (perceptual) abilities. The critical auditory factors of binaural summation (or integration) and resistance to distortion have been utilized in evaluating the central auditory abilities of children manifesting severe speech-language delay patterns. The investigator has felt that these same techniques and others could be employed in the evaluation of central auditory sensitivities which could be directly related to the childs' ability to learn phonics and later, to read.

During the past few years, much emphasis has been placed on

reading, phonics and audition. Durrell, Nicholson, Olson, Gavel and Linehan (1958) identified specific phonic abilities considered to be necessary for success in first grade reading. Earlier work by Durrell and Murphy (1953) demonstrated the importance of auditory discrimination in reading readiness and in reading problems. Huset (1961) suggested that the ability referred to as "auditory blending" could be an indicator of basic, pervasive neurological involvement in cases of reading disability. In a most recent study, Chall, Roswell and Blumenthal (1963) observed that "auditory blending ability has a substantial relationship to reading achievement, especially to word recognition and analysis. Poor auditory ability may signify a defect or a lag in neurophysiological development."

In a current study, Flowers and Costello (1964) investigated the relationship of certain phonic abilities considered to be critical in success in first grade reading and the resistance to distortion factor in auditory perception. Second semester kindergarten children were utilized in this study. The investigators found a significant positive relationship between the perception of distorted words and the following phonic abilities: (1) identifying lower case letters named; (2) identifying capital letters named; (3) sounds capital letters make; and (4) making peoples names out of capital letters. The authors postulated that filtering of words at optimum low pass levels could provide a sensitive evaluation of the child's higher levels of hearing, particularly as related to the perception of phonic elements utilized in reading readiness skills.

In view of the work reviewed here, there appears to exist a

relationship between various auditory skills considered to be critical in the process of reading learning (skills, eg: phonic abilities; auditory discrimination; auditory blending ability) and basic auditory perceptual abilities. For a school aged child to learn phonic and other auditory skills, he must possess the basic auditory perceptual skills required to proceed into more complex auditory learning situations. The assessment of these skills could be of primary educational value. To date, it appears that some of the new audiological procedures, eg: low pass filtered speech; accelerated speech (resistance to distortion); binaural summation; synthesis and/or integration; and the competing messages procedures could be utilized as diagnostic instruments in the evaluation of the central mechanism of hearing in children. Specifically, some of these techniques may be of diagnostic assistance in such language problems as delayed speech, infantile aphasia, and hopefully, in reading retardation and various forms of mental retardation. Significant research studies employing these audiological procedures - and relating to the experimental conditions of the present research - will be reviewed.

A. Low Pass Filtered Speech - (FS)

French and Steinberg (1947) demonstrated that in high pass filtering at 1000 c.p.s. an articulation score of 90% was obtained (for nonsense syllables), whereas a low pass filter at the same cut off level allowed for an articulation score of only 27%. Hirsh, Reynolds and Joseph (1954) also indicated that eliminating all frequencies - by filtering - below 1600 c.p.s. does not impair the intelligibility of words seriously. Finally, Miller and Nicely (1955)

concluded that audibility is the problem for high pass systems, and confusibility being the predominent difficulty in low pass filtering.

Further use of the filtered speech signal in conjunction with the binaural summation principle provided audiology with a sensitive diagnostic procedure in the investigation of central nervous system pathology, and possibly in the assessment of central auditory-sound discrimination abilities. Bocca, Calearo, Cassinari and Migliavacca (1955) tested patients with supratentorial cerebral tumors by utilizing a low pass filter system at about 1000 c.p.s. Their findings stressed that in nearly all cases observed, the articulation score for distorted speech in each ear separately was assymetric. The scores were significantly lower in the ear contralateral to the lesion. Bocca (1955) in a separate study with normal hearing subjects, developed a procedure employing filtered and subthreshold auditory stimuli to test what he termed "binaural summation." Bocca, and subsequently Calearo (1957), in a follow-up study testing subjects with lesions of the temporal lobe, provided evidence that summation ability was absent in cases where there was impairment of the cortical auditory area. Both authors concluded that their tests could be useful as instruments in the evaluation of the efficiency of the central mechanism of hearing. Flowers and Costello (1963) adapted the "Binaural Summation" technique to evaluating the central mechanism of hearing of speech defective and normal speaking children. Their results indicated that speech defective children had significantly more difficulty with the distorted speech material.

B. Accelerated Speech - (AS)

Another approach to distorting speech is by compressing it for an effect of acceleration without altering the frequency spectrum. Fairbanks, Everitt and Jaeger (1954) were among the first to experiment with recorded compressed speech material in an effort to present the signal in less than the normal original time without altering other dimensions of the original signal. Fairbanks, Gutman and Miron (1957) presented two technical messages at various percentages of compression of the original message, and discovered that factual comprehension is significantly effected by: (1) time compression; (2) listener aptitudes; and (3) message effectiveness.

Accelerated speech has also been utilized in pathological conditions by Calearo and Lazzaroni (1957) who maintained that accelerated speech involved a strain on the patients' superior auditory centers, thus making normal discrimination possible only when these higher auditory mechanisms were completely unimpaired. The authors further suggested that accelerated speech could become a useful approach for the evaluation of the "superior auditory function". Harris, Haines, and Myers (1960) tested adult males with high frequency hearing losses and normal hearing men. A test designed to "speed-up" words as a temporal distortion simulating everyday conditions encountered by the normal hearing and hearing defective person was utilized. It was found that in the normal hearing group, rapid speech was handled well as long as accurate articulation patterns were maintained by the speaker. Hearing defectives with losses from 20 to 65 decibels at 3000 c.p.s. had

distinct disturbances in understanding the sentence material presented. The authors concluded that "a normal or near normal audiogram at 3 KC is essential for high sentence intelligibility if stress is put upon the speech signal through a speed-up." Foulke, Amster, Nolan and Bixler (1962) employed a method of speech compression to accelerate the speech signal without appreciably altering the basic characteristics of the message. The authors used this technique in an attempt to assess the listening comprehension of accelerated speech by blind students. Costello and Flowers (1964) employed the Foulke, et.al. method of speech compression in a study of children manifesting severe speech-language delay. Their results indicated some difficulties in the perception of rapid speech by the speech defective children as compared with their normal speaking peers.

C. Dual Distortion - (DD)

No precedence could be found for this condition. Since both methods of distortion - accelerated and filtered speech - have been thoroughly discussed above, the same related research studies apply to this condition. The present investigator felt a need to experiment with two forms of distortion since children in the school situation often encounter various forms of distorted stimuli, often simultaneously, eg: the accelerated rate of speech of a teacher; the background noise in a classroom; faulty articulation patterns of teachers and peers; etc.

D. Competing Messages - (CM)

The task of listening to two messages or two separate word

stimuli at once has been investigated and workers generally agree that an increase in the amount of information presented causes a relative decline in efficiency. Cherry (1953) demonstrated that a listener can, after repeated presentations, separate out two different speech passages, recorded by the same voice on the same tape. Peters (1954) has shown that unwanted speech which is similar in content to the wanted message produces greater difficulty than does a dissimilar background. Broadbent (1954) presented pairs of messages simultaneously, requiring an answer to only one of the messages. The investigator found that spatial separation of loud speakers was a help to listeners as was stereophonic separation. Poulton (1956) discovered a drop in relative efficiency when two relevant messages arrived simultaneously, as compared with isolated messages or with the simultaneous arrival of relevant and irrelevant messages.

In pathological conditions, Carhart, Pollock, and Lotterman (1963) tested the efficiencies of four groups of 12 subjects each, when listening to PB material presented against competing sentences and reproduced binaurally through matched hearing aids. The groups consisted of normal hearers, patients with conductive losses, and two groups manifesting sensory-neural hearing defects. The results indicated that performance for all groups was reduced in a monaural indirect condition, and this reduction increased sharply as the intensity ratio between the primary and competing message was made more unfavorable.

IV. Procedure

A. Subjects

Subjects were 91 third grade public school children from the Perth Central School, Perth, New York. The subjects were divided into two groups: (1) control group (normal reading), consisting of 41 subjects; and (2) experimental group (low reading) consisting of 41 subjects. The criteria for selection of the groups were as follows:

Control, normal reading group:

(1) each subject was tested and found to be in the top 45% of the third grade total of 91 children in reading achievement as measured by the Stanford Achievement Test. The test was administered within one month of the time of administration of the experimental conditions;

(2) the subjects were judged by their teachers (subjective appraisal) as belonging to the normal reading group;

(3) subjects were above the 85 I.Q. delimiting point as determined by the California Mental Maturity Scale (the test was administered within three months of the administration of the experimental condition);

(4) subjects successfully passed a pure tone air conduction audiometric test binaurally at +10 db, re: normal threshold for 250, 500, 1000, 2000 and 4000 c.p.s.;

(5) subjects were free of any observable and recorded gross organic and/or emotional abnormalities (including uncorrected

peripheral vision).

Experimental, low reading group:

(1) each subject was tested and found to be in the lower 45% of the third grade total of 91 children in reading achievement, as measured by the Stanford Achievement Test. (Of the 41 subjects assigned to this classification, 29 were considered to be below grade level in reading.);

(2) subjects were judged by their teachers as belonging to the lower reading group (a large percentage of the below grade level subjects were considered to be candidates for remedial reading by their teachers and the administration);

(3) subjects were above the 85 I.Q. delimiting point as determined by the California Mental Maturity Scale;

(4) subjects successfully passed a pure tone air conduction audiometric test binaurally, at +10 db, re: normal threshold for 250, 500, 1000, 2000 and 4000 c.p.s.;

(5) subjects were free of any observable and recorded gross organic and/or emotional abnormalities (including uncorrected peripheral vision).

In addition to the tests mentioned above, all subjects were given the Peabody Picture Vocabulary Test to determine their hearing vocabulary level.

The ranges of average reading scores for both groups are presented in Table 1.

Table 1.

Average reading score ranges and means for the Experimental and Control Groups as determined by the Stanford Achievement Test.

(N=41 for each group)

Group	Ranges of Average Reading Scores	Means
Control (normal readers)	4.4 - 6.9	5.31
Experimental (low readers)	1.85 - 4.1	3.32

B. Apparatus

All of the test material was recorded in a sound proof, sound treated room. For Condition I (Low Pass Filtered Speech), the sentences were passed through an Allison Model 21 Audiometer and an Allison Variable Frequency Filter Model 3B (30 db per octave cut off), and recorded on a single channel Ampex 301 magnetic tape recorder. For Condition II (Accelerated Speech), previously compressed materials (processed by a Tempo-Regulator, Dr. Emerson Foulke, Department of Psychology, U. of Louisville, Kentucky) was recorded in the same manner as Condition I. For Condition III (Dual Distortion), speech material on an accelerated speech tape was passed through the same audiometer and filter as described above, and recorded in the same manner as in Condition I. For Condition IV (Competing Messages), speech material and a childrens' story were passed through a Beltone 15C Audiometer and recorded on an Ampex 1270 dual channel tape recorder.

C. Method and Instrumentation

1. Condition I, Low Pass Filtered Speech (FS)

Twenty-five pre-recorded completion type sentences (see

Appendix A) were presented binaurally through Telex Dyna Twin HDP-53A earphones at +40 db, re: normal threshold. The pre-recorded speech material was distorted by low pass filtering at 960 c.p.s. and presented through the earphones via a Beltone 15C audiometer and Ampex 1270 tape recorder. Each subject was required to listen to a sentence, eg: "The cowboy rides a _____", he was then confronted with a choice of three pictures for his answer, in the example the pictures were goat, horse, cow. If he did not point to a horse, the response was graded wrong.

2. Condition II, Accelerated Speech (AS)

Fifteen pre-recorded completion type sentences (see Appendix B) and 16 phonetically controlled words (criteria for construction described in Flowers and Costello, 1963, see Appendix B) were presented binaurally through Telex Dyna Twin HDP-53A earphones at +40 db, re: normal threshold. The pre-recorded speech material was accelerated to a rate of 280 words per minute and presented through earphones via a Beltone 15C audiometer and Ampex 1270 tape recorder. For the sentence section of this condition, the subject was required to complete a sentence verbally without the benefit of picture selection, eg: the subject heard the sentence: "The hunter shot the deer with a _____". If he did not say gun, rifle or some other appropriate word, his answer was recorded as being wrong. For the phonetically controlled words, only the consonant sound in the final position was tested. Earlier experimentation indicated that the isolated accelerated words were not very difficult to perceive, therefore, the investigator decided to increase the difficulty

of this task by testing only the final consonant, which is much more difficult to perceive in that position because of the intensity decay which occurs in sounds occurring at the end of a word.

3. Condition III, Dual Distortion (DD)

Fifteen pre-recorded sentences and 16 phonetically controlled words (see Appendix C) similar to those described in Condition II were presented in the same manner as described in Condition II. The speech material was first accelerated to a rate of 210 w.p.m. and then further distorted by a low pass filter at 1600 c.p.s. Subjects were expected to respond in the same manner verbally as described in Condition II. Only the initial consonant sounds were tested in the phonetically controlled words section of this condition. Dual distortion imposes additional hardship in perception, therefore, the scoring was confined to the initial sound in the word to avoid complete lack of discrimination ability on the part of the subjects.

4. Condition IV, Competing Messages (CM)

A list of 50 PBK words (kindergarten phonetically balanced word list 1., developed by Harriet L. Haskins, Johns Hopkins Hospital, see Appendix D) were presented via sound field by an Ampex 1270 tape recorder on channel I at +60 db, re: normal threshold, by a well articulated female speaker. Channel II of the same recorder simultaneously presented a childrens' story (see Appendix D) at exactly the same intensity by the same female speaker. The PBK words were the designated meaningful message while the childrens' story was the intended competing and/or interfering message.

The speaker separation on the Ampex 1270 tape recorder was fifteen inches. The subjects were seated at midpoint between the speakers at exactly six feet from the tape recorder. The speakers were placed at ear level of the subjects. Each subject was instructed to listen and respond to the PBK words while ignoring the childrens' story. Scoring was accomplished in the same manner as an audiological PB Max procedure. Each PBK word was preceded by the carrier phrase "say the word _____".

V. Analyses of the Data and Findings

To adequately test the original hypotheses proffered in this study, the following statistical analyses were performed: (1) multiple product moment correlation coefficients were obtained (between reading achievement and all measures of central auditory abilities) on the total sample of 91 children tested, including the middle 10% (9 children) who were excluded from the comparison of groups portion of the analysis; and (2) the normal and lower group means were compared for significant statistical differences on all measures of central hearing.

Multiple correlation coefficients in matrix form are presented in Table 2. (Levels of significance for individual correlation coefficients are indicated by single or double asterisk notation next to the significant rs within the matrix proper).

Table 2.

Multiple Correlation Coefficients in Matrix Form
(N=91)

Var.	1. (Stanf.) Read. Achiev.	2. FS	3. AS	4. AW	5. CM	6. DDS	7. DDW	8. Peab. Raw Score	9. Cal. I.Q.	10. CA
1	1.00	.42*	.30*	.11	.26**	.16	.22**	.53*	.61*	.03
2		1.00	.25**	-.01	-.00	.26**	.09	.33*	.40*	.06
3			1.00	.21**	.21**	.23**	.17	.35*	.12	.01
4				1.00	.09	-.03	.04	.09	.17	.01
5					1.00	-.07	.06	.07	.10	-.20
6						1.00	.30*	.28*	.18	.09
7							1.00	.21**	.28*	.15
8								1.00	.43*	.02
9									1.00	.11
10										1.00

*significant at .01 level
**significant at .05 level

It should be specifically noted that the total N(91) - the middle 10% in addition to the upper and lower 45% comprising the normal and lower group readers - was utilized in the correlation study to determine the predictive value of the experimental procedures with respect to reading achievement relative to a randomly selected sample of third grade children.

The highest and most significant r_s were found between reading achievement and the following central auditory abilities tests in rank order: (a) filtered sentences ($r = .41$, $p < .01$); (b) accelerated sentences ($r = .31$, $p < .01$); (c) competing messages ($r = .26$, $p < .05$); (d) dual distorted words ($r = .22$, $p < .05$). While the FS procedure yielded far and away the highest r, the CM approach just barely missed being significant at the .01 level of confidence.

Significant correlation coefficients of interest among distortion measures and other variables common to all subjects were:

(a) for the filtered sentences procedure, the accelerated sentences condition yielded an r of .25, and the dual distorted sentences procedure produced an r of .26 (both significant at .05 level). This could be expected since all three conditions are measures of resistance to distortion in some form, and all three tests were composed of sentences of relatively equal length and degree of difficulty. The FS procedure also furnished r_s significant at the .01 level with the Peabody raw scores (r = .33) and the California I.Q. scores (r = .40);

(b) for the accelerated sentences procedure, significant correlations were recorded for the FS, CM, DDS and accelerated words. All but the significant r for CM could be anticipated. Although a high r (.35, $p < .01$) was obtained between AS and the Peabody scores, no significant r was found for the California I.Q. test;

(c) for the competing messages approach, no significant r_s resulted other than those reported for reading achievement and accelerated speech. Unlike the FS, AS and DDW conditions, the CM procedure yielded no significant r_s with respect to Peabody scores or the California I.Q. results. The CM test was also independent of all other measures of distortion - save the AS - while retaining its significant r (.05) with reading achievement;

(d) for the dual distorted words procedure, significant r_s were recorded for the Peabody and California scores and the dual distorted sentences as could be expected from the trend developed

by the other measures of distortion.

Of the total battery employed in this study, only the accelerated words and dual distorted sentences procedures failed to produce significant correlations with reading achievement. It is also significant to note that all measures of central auditory ability had non-significant r_s with respect to chronological age. Strangely enough, the CM condition produced a non-significant but relatively high negative r (-.20) for chronological age.

The means, t scores, and levels of significant differences for the experimental and control groups for each of the experimental procedures, and for the Peabody, I.Q. and CA measures, are presented in Table 3.

The significant differences found between means of the normal and lower group readers on each measure of central hearing, support the data obtained in the correlation matrix.

Table 3.

Results of t tests for evaluation of mean differences between Normal and Lower reading groups for each test employed.

	Means			
Test	Normal Group	Lower Group	t scores	p
FS	19.71	17.41	3.83	.01
AS	13.78	12.97	2.86	.01
AW	14.39	14.29	.38	NS
CM	82.34	76.24	3.19	.01
DDS	7.76	7.26	.96	NS
DDW	9.15	8.12	2.64	.02
Peabody	78.83	71.34	4.57	.01
I.Q.	118.90	105.76	5.24	.01
CA	8.77	8.75	.22	NS

VI. Conclusions and Implications

The most significant results of this study suggest that the measures of central auditory abilities utilized in this study may have prognostic and limited diagnostic value with respect to reading achievement and/or disability.

The correlation coefficients obtained on reading achievement scores and various tests of central hearing indicate that the majority of these procedures could be of predictive value in future reading achievement and possibly in predicting future reading difficulty. Since most r_s were not greater than .40, the measures can be assumed to be generally useful for group type predictions at this time. It would be reasonable to assume that these predictions would be more closely and specifically related to difficulties in phonics learning.

The filtered sentences technique appears to be one of the most promising measures since it produced the highest correlation coefficient with respect to reading achievement. In addition to this circumstance, the FS results hold well with the results obtained in a previous study (Flowers and Costello, 1964) which indicated that filtered speech perception correlated significantly with various phonic abilities considered by Durrell, et.al. (1958) to be necessary for success in first grade reading. The reader must be cautioned, however, that the high r_s obtained between FS and the Peabody and California measures suggest some dependence of the FS material on receptive vocabulary level and I.Q. This is acceptable, however, since the test was not designed to differentiate normal

and sub-normal intellectual capacities of this sample of children. These findings contradict statements made by Bocca and Calearo (1963) that measures of central hearing are little influenced "by the education, intelligence, and vocabulary capacity of the subjects."

The accelerated sentence condition - with the next highest r - appears to be a promising approach which needs considerably more rigorous investigation relative to sensitive rates of acceleration. Its highly significant relationship to the Peabody measure suggests a possible dependence on receptive vocabulary level, however, the measure's lack of correlation with I.Q. appears to recommend it for further scrutiny. The measure may be helpful in the assessment of central auditory abilities of children suspected of some form of mental handicap.

The dual distorted words procedure furnished the lowest significant r with regard to reading achievement, and its apparent relation to receptive vocabulary level and I.Q. suggests careful consideration of the merits of the measure. If one also considers the fact that the dual distorted words were very carefully controlled phonetically and bore no resemblence to connected speech, one would have to cast some doubt as to the efficacy of this technique in predicting future reading ability, especially in view of the much more favorable results provided by the other tests of distortion. The test in its present form, is not being considered for further experimentation by the investigator.

The results of the competing messages approach offer the most

intriguing possibilities for future study. The measure's apparent independence with respect to receptive vocabulary and I.Q., seems to recommend it highly as a prognostic instrument not only with regard to children considered as "normal" in mentality, but also with populations suspected of some intellectual impairment and/or deficiency. The measure's relative lack of relationship to other measures of central hearing - with the exception of the accelerated sentence approach - strongly suggests that the CM technique may be evaluating different neuroanatomical and functional aspects of the central mechanism of hearing. Some support for this contention may be offered if one is disposed to consider the nature of the measures utilized in this study. The FS, AS, and DDW procedures are tests of "resistance to distortion" and have been suggested as evaluating that portion of the central mechanism of hearing referred to as the area of the "third neuron" at the cortical and/or sub-cortical levels (Bocca and Calearo, 1963). It is the contention of this writer that the CM procedure can be more adequately described as a test of auditory dedifferentiation, (Winchester and Hartman, 1955), which is commonly accepted as a function of auditory figure-background differentiation. This may be the highest level of central auditory function. The CM's negative correlation with chronological age might suggest to some workers that the higher the CM score, the lower the child's CA, however, the writer must caution the reader that the very narrow range of chronological age employed in this study, would cast serious doubt relative to such a conclusion.

It appears appropriate to mention that the very low,

non-significant correlations between CA and the various tests of central hearing, clearly establish independence of central auditory abilities measures on chronological age. It may be further postulated that some dependence of the measures on I.Q. and receptive vocabulary skill may be tolerated, since it would be expected that most children in the public school reading program are within the bounds of normal I.Q. and receptive vocabulary level. Further work should be initiated with children in lower I.Q. classifications for diagnostic purposes, relative to mentally handicapped populations, especially with the CM and possibly with the AS techniques.

The significant statistical differences found between the means of the normal and lower groups on various tests of distortion support the significant r_s obtained in the correlation analysis, however, it would be difficult to speculate how useful these techniques would be diagnostically. The highest t scores (FS; AS; CM; significant at the .01 level, and the DDW significant at the .02 level) clearly indicate that these measures differentiate normal from lower group readers, however, the fact that the highest r between reading achievement and the central hearing tests was only .41, indicates that there would be considerable question as to the usefulness of these techniques for diagnostic purposes at this time. On the other hand, some diagnostic assistance may be derived from these measures with respect to the types of central auditory disturbances children may be manifesting. On this point, much more work needs to be conducted with other tests of central auditory hearing (eg: binaural synthesis and/or summation) and on children

who are suspected of having specific CNS hearing difficulties.

In conclusion, it may be stated that the measures of central hearing employed in this study suggest that they may be of predictive value, relative to reading achievement and/or disability, however, further work is recommended along the lines of longitudinal studies. Central auditory abilities of children should be evaluated in kindergarten, or perhaps as early as the pre-school level, to determine the predictability of these measures, relative to future reading achievement and disability in the elementary grades. Furthermore, we may be relatively confident that these measures may provide early identification of children who may encounter difficulties in learning phonics in the reading readiness program. Further work should be initiated with children suspected of having different kinds of central auditory disturbances by employing various types of central hearing measures. It would also be helpful to compare normal, lower, and remedial reading groups on various tests of central hearing, with the express purpose of developing clinical diagnostic instruments in this vital area.

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A. Condition I
Low Pass Filtered Sentences

1. Mother hangs the clothes with /clothes pins.
2. The cowboy rides a /horse.
3. Mother wears this when she cooks /apron.
4. At night, this shines in the sky /star.
5. Father smokes a /pipe.
6. The girl poured the juice from the /pitcher.
7. An animal with a long trunk is an /elephant.
8. I carry water in the /bucket.
9. When it gets hot, we turn on the /fan.
10. At the circus I saw a /clown.
11. Mother puts on the baby's diapers with a /pin.
12. The woodsman cut the tree down with the /saw.
13. An animal that growls is a /tiger.
14. Mother wears this on her head /hat.
15. The artist paints with /brushes and pallet.
16. We use these to see with /eyes.
17. The boy spins the /top.
18. Mother cleans the house with a /mop.
19. The girl took the picture with a /camera.
20. A cowboy uses a /gun.
21. In autumn, this falls off the trees /leaf.
22. This lives in the ocean /fish.
23. Mother irons the clothes on an /ironing board.
24. Father wears this around his neck /tie.
25. At Christmas, we eat /turkey.

B. Condition II
Accelerated Sentences

1. The hunter shot the deer with a /gun.
2. Out West, cowboys ride on a /horse.
3. When we send a letter, we put it in a /mailbox.
4. All dogs like to chew on a /bone.
5. Mother cooks our breakfast on a /stove.
6. When we are thirsty, we drink water from a /glass.
7. Every morning, father drives to work in a /car.
8. Baseball players hit the ball with a /bat.
9. The carpenter hit the nail with a /hammer.
10. Some Indians shoot with a bow and /arrow.
11. The boy caught a baseball with a /glove.
12. Mother drinks her coffee from a /cup.
13. During our vacation, we took pictures with a /camera.
14. On a farm, the farmer milks a /cow.
15. At the zoo, the monkey ate a /banana.

B. Condition II
Phonetically Controlled Accelerated Words
(Test final position consonants)

1. sip
2. fib
3. mit
4. lid
5. sick
6. fig
7. jif
8. live
9. with
10. miss
11. his
12. dish
13. witch
14. ridge
15. her
16. fill

C. Condition III
Dual Distortion of Sentences

1. A large animal in a circus is an /elephant.
2. When we dress, we put a shoe on our /foot.
3. An animal that barks loud is a /dog.
4. A soldier must always salute the /flag.
5. We must be careful when we cut paper with /scissors.
6. When we eat dinner, we sit on a /chair.
7. We read a book with our /eyes.
8. For dessert, we had a delicious piece of /cake.
9. After dinner, father likes to smoke a /pipe.
10. In spring, leaves begin to grow on a /tree.
11. Mother takes baby for a ride in a /buggy.
12. Bugs Bunny, the rabbit, likes to eat /carrots.
13. Father paints the house with a /brush.
14. Santa Claus comes into a house through a /fireplace.
15. During war, a soldier drives a /tank.

C. Condition III
Phonetically Controlled Dual Distortion Words
(Test initial position consonants)

1. pitch
2. Bill
3. tin
4. ditch
5. kiss
6. give
7. fit
8. Vic
9. thick
10. this
11. sit
12. ship
13. chip
14. Jim
15. rib
16. lip

D. Condition IV
Competing Messages

PBK List 1.

1. please
2. great
3. sled
4. pants
5. rat
6. bad
7. pinch
8. such
9. bus
10. need
11. ways
12. five
13. mouth
14. rag
15. pat
16. fed
17. fold
18. hunt
19. know
20. box
21. are
22. teach
23. slice
24. is
25. tree
26. smile
27. both
28. slip
29. ride
30. end
31. pink
32. thank
33. take
34. cart
35. scab
36. lay
37. class
38. me
39. dish
40. neck
41. beef
42. few
43. use
44. did
45. hit
46. pond
47. hot
48. own
49. bead
50. shop

D. Condition IV
Competing Messages

Childrens' Story

Little Brown Bear, by Elizabeth Upham, The Platt & Munk Co., Inc., Publishers, New York.

Little Brown Bear Loses His Clothes

Halfway up Blueberry Hill, in a funny old yellow house, lived Little Brown Bear.

Little Brown Bear liked to hunt for honey, he liked to sit on the steps of the old yellow house, and he liked to lie in the hammock under the mulberry tree --- but he didn't like to hang up his clothes when he went to bed.

Every night when Little Brown Bear was ready to go to bed, plop! Down on the floor went his nice red coat, his new checkered shirt, and his handsome little gray trousers. And Plop! Into one corner went his polka dot silk tie, and onto the chair went his little straw hat.

Pouf! Out went the candle.

Whisk! Under the covers went Little Brown Bear.

One night Round Mr. Moon looked down through the window into Little Brown Bear's room and called out loudly:

"Such an untidy room for a good little bear!
Coat on the floor, hat on the chair!"

But Little Brown Bear turned over in bed, pulled the covers around his ears, and pretended he hadn't heard a word that Round Mr. Moon had been saying.

Soon Old Mr. Owl looked in through the window and called out very loudly:

"To whit, to whoo! To whit, to whoo!
Such a careless thing for a bear to do!"

But Little Brown Bear just turned over in bed and pulled the covers higher over his ears and pretended he hadn't heard a word that Old Mr. Owl had been saying.

By and by Mr. Wind came whistling round and round the old

D. Childrens' Story (cont.)

yellow house. He called through the window very, very loudly:

"Little Brown Bear, don't wait, don't wait!
Hang up your clothes before it's too late!"

But that foolish little bear only turned over in bed, pulled the covers still higher over his ears, and pretended he hadn't heard a word that Mr. Wind had been saying.

Then WHOOP! Mr. Wind blew right in through the window and whisked up Little Brown Bear's nice red coat, his new checkered shirt, and his handsome little gray trousers. Then WHOOP! He blew again, and away went Little Brown Bear's polka dot silk tie and his little straw hat.

In the morning Little Brown Bear jumped out of bed bright and early. He was going to take his shiny tin pail and go to the woods after blueberries.

But he couldn't find his clothes!

He looked for them everywhere. He looked upstairs and downstairs. He looked in every corner and under the furniture. But he could not find them.

So Little Brown Bear put on his last year's old patched overalls and sat down on the steps of the yellow house and cried and cried.

By and by he heard Mrs. Duck calling out as she hurried down the hill:

"You're all invited to come to tea
Down in my garden at half-past three."

That made Little Brown Bear feel very bad indeed, and he cried and cried harder than ever. For of course he couldn't go to Mrs. Duck's tea party in his last year's old patched overalls.

So he just sat there in the sun, thinking and crying and crying and thinking and thinking and crying.

Suddenly, out of all that thinking, a thought popped right into Little Brown Bear's head!

FINAL SUMMARY

CENTRAL AUDITORY ABILITIES OF NORMAL AND LOWER GROUP READERS

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BACKGROUND

The importance of phonic skills in the reading program has indicated a need for evaluation of basic perceptual skills underlying the ability to learn phonics. Children who manifest reading deficiency in the grades have been identified as having auditory perceptual difficulties in such areas, eg: auditory discrimination, phonics blending and applied phonics. To date, discreet techniques in identifying auditory perceptual factors underlying these abilities and/or disabilities have not been utilized with elementary school children who exhibit reading difficulty.

Recent attempts by audiologists have developed and suggested new behavioral audiometric techniques which presume to evaluate the central auditory mechanism. Central auditory abilities are considered to be auditory perceptual skills basic to all auditory skills involved in all aspects of language learning, including speech, hearing and reading. The significance of the new audiological approaches of "frequency distortion", "synthesis" and "dedifferentiation" lies in the possibility that these techniques may be developed to identify kindergarten and possibly pre-school children with sub-normal central auditory mechanisms, and it is possible that these new methodologies may be of diagnostic and prognostic assistance in identifying and predicting future reading problems in elementary school children with respect to the auditory aspect of reading learning.

OBJECTIVES

The research reported herein was designed to achieve the following goals:

(1) To evaluate the central mechanism of hearing of early elementary school aged children in a regular public school reading program, by employing the following behavioral audiometric techniques: (a) low pass filtered speech; (b) accelerated speech; (c) dual distorted speech; and (d) competing messages.

(2) To compare the auditory and the perceptual abilities of children who can do the normal reading for the grade and those who cannot.

(3) To search for relations between reading achievement and central auditory skills.

PROCEDURE

1. Subjects

Subjects were 91 third grade public school children from the Perth Central School, Perth, New York. The subjects were divided into two groups: (1) control group (normal reading), consisting of 41 subjects; and (2) experimental group (low reading), consisting of 41 subjects. The criteria for selection of the groups were as follows:

Control, normal reading group, subjects were:

(a) tested and found to be in the top 45% of the third grade total of 91 children in reading achievement as measured by

the Stanford Achievement Test;

(b) above the 85 I.Q. delimiting point as determined by the California Mental Maturity Scale;

(c) judged by their teachers (subjective appraisal) as belonging to the normal reading group;

(d) tested and successfully passed a pure tone air conduction audiometric test binaurally at +10 db, re: normal threshold for 250, 500, 1000, 2000 and 4000 c.p.s.; and

(e) free of any observable and recorded gross organic and/or emotional abnormalities (including uncorrected peripheral vision).

Experimental, low reading group, subjects were:

(a) tested and found to be in the lower 45% of the third grade total of 91 children in reading achievement as measured by the Stanford Achievement Test;

(b) judged by their teachers as belonging to the lower reading group (a large percentage of the below grade level subjects were considered to be candidates for remedial reading by their teachers and the administration);

(c) above the 85 I.Q. delimiting point as determined by the California Mental Maturity Scale;

(d) tested and successfully passed a pure tone air conduction audiometric test bimaurally at +10 db, re: normal threshold for 250, 500, 1000, 2000 and 4000 c.p.s.; and

(e) free of any observable and recorded gross organic and/or emotional abnormalities (including uncorrected peripheral

vision).

In addition to the tests mentioned above, all subjects were given the Peabody Picture Vocabulary Test to determine their receptive vocabulary level.

2. Techniques and Instrumentation:

(a) Condition I, Low Pass Filtered Speech (PS)

Twenty-five pre-recorded completion type sentences were presented binaurally through earphones at +40 db, re: normal threshold. The pre-recorded speech material was distorted by low pass filtering at 960 c.p.s. and presented through the earphones via an audiometer and tape recorder. Each subject was required to listen to a sentence, eg: "The cowboy rides a _____", he was then confronted with a choice of three pictures for his answer, in the example the pictures were goat, horse, cow. If he did not point to a horse, the response was graded wrong. The data gathered were composed of the number of correct responses to the sentences presented.

(b) Condition II, Accelerated Speech (AS)

Fifteen pre-recorded completion type sentences and 16 phonetically controlled words were presented binaurally through earphones at +40 db, re: normal threshold. The pre-recorded speech material was accelerated to a rate of 280 words per minute and presented through earphones via an audiometer and tape recorder. For the sentence section of this condition, the subject was required to complete a sentence verbally without the benefit of picture selection, eg: the subject heard the sentence: "The hunter shot the deer with a _____". If he did not say gun, rifle, or some

other appropriate word, his answer was recorded as being incorrect. For the phonetically controlled words, only the consonant sound in the final position was tested. Data gathered for the sentence condition were the same as described in "Condition (I)". For the phonetically controlled word stimuli, the number of correct final sounds repeated was recorded.

(c) Condition III, Dual Distortion (DD)

Fifteen pre-recorded sentences and 16 phonetically controlled words similar to those described in Condition II, were presented in the same manner as described in Condition II. The speech material was first accelerated to a rate of 210 w.p.m. and then further distorted by a low pass filter at 1600 c.p.s. Subjects were expected to respond in the same manner verbally as described in Condition II. Only the initial consonant sounds were tested in the phonetically controlled words section of this condition. Data gathered were the same as described in "Condition (II)" above.

(d) Condition IV, Competing Messages (CM)

A list of 50 PBK words (kindergarten phonetically balanced word list 1.) were presented via sound field by a tape recorder on channel I at +60 db, re: normal threshold, by a well articulated female speaker. Channel II of the same recorder simultaneously presented a childrens' story at exactly the same intensity by the same female speaker. The PBK words were the designated meaningful message, while the childrens' story was the intended competing and/or interfering message. The speaker separation on the tape recorder

was fifteen inches. The subjects were seated at midpoint between the speakers, at exactly six feet from the tape recorder. The speakers were placed at ear level of the subjects. Each subject was instructed to listen and respond to the PBK words, while ignoring the childrens' story. Scoring was accomplished in the same manner as an audiological PB Max procedure. Each PBK word was preceded by the carrier phrase, "say the word _____". The data gathered were the percentages of correct word repetitions uttered by the subjects.

3. Statistical Analysis:

Multiple correlation coefficients were performed between reading achievement, I.Q., CA, receptive vocabulary level, and all measures of central auditory abilities. The correlation analysis was performed on the total sample of 91 subjects, including the middle 10% of children excluded from the normal and lower reading groups. Tests for determining significant differences (t tests) between means of the normal and lower group readers were also employed.

RESULTS

(1) Highest and most significant correlation coefficients were found between reading achievement and:

(a) filtered sentences ($r = .41$, $p < .01$)

(b) accelerated sentences ($r = .31$, $p < .01$)

(c) competing messages ($r = .26$, $p < .05$)

(d) dual distorted words ($r = .22$, $p < .05$)

(2) The "resistance to distortion" measures (filtered,

accelerated, dual distorted sentences) generally were related to I.Q. and receptive vocabulary level (as measured by the Peabody test), and each of the distortion measures correlated significantly with each other.

(3) The competing messages results demonstrated complete independence of I.Q. and receptive vocabulary level, and did not correlate significantly with any of the other distortion measures except accelerated sentences.

(4) All measures of central auditory abilities produced non-significant correlation coefficiants with chronological age.

(5) Significant differences found between means of the normal and lower group readers on each measure of central hearing, supported the data obtained in the correlation study. Significance levels between groups for each measure were:

(a) accelerated sentences	.01
(b) filtered sentences	.01
(c) accelerated words	NS
(d) competing messages	.01
(e) dual distorted sentences	NS
(f) dual distorted words	.02

(6) There were significant differences between the normal and lower reading groups on I.Q. and receptive vocabulary level.

CONCLUSIONS AND IMPLICATIONS

(1) The significant correlation coefficients obtained between reading achievement and the tests of central auditory abilities

indicate that the measures of central hearing may be of prognostic value relative to future reading achievement and/or disability. It may be possible to test kindergarten and perhaps pre-school children to predict future difficulties.

(2) Tests of central auditory abilities may be capable of early identification of children (in kindergarten and possibly at the pre-school level) who will experience difficulty in phonics learning in the reading readiness program.

(3) Although t scores were significant in most group comparisons, it is not possible to definitely state that measures of central hearing could differentiate normal and lower group readers diagnostically.

(4) The nature of the central hearing measures may be of diagnostic assistance relative to the types of central auditory disturbance a child may be experiencing.

(5) Although most measures of central auditory abilities are related to I.Q. and receptive vocabulary level, the tests may be used with normal school populations, since it is assumed that there is a strong relationship between reading achievement and I.Q.

(6) The competing messages technique - and possibly the accelerated sentences approach - might be useful in evaluating the central mechanism of hearing of children considered to be mentally handicapped and/or brain damaged.

(7) Further studies should be initiated with particular reference to those of the longitudinal type. Kindergarten or pre-school aged children should be tested for central auditory function with

the results correlated with later elementary school reading achievement.

(8) Further studies should be initiated to determine the diagnostic value of central auditory tests with children who manifest different kinds of auditory disability in relation to specific reading and language dysfunction, (eg: remedial reading cases, spelling difficulty, speech defectives, etc.).

BIBLIOGRAPHY

There are 30 references listed in the final report.